

## CHAPTER IX

### CHEMICAL STORAGE, HANDLING AND APPLICATION

#### A. BASIC CONSIDERATIONS

1. PLANS AND SPECIFICATIONS – Plans and specifications submitted to KDHE for review and consideration for approval shall include:
  - a. Feed equipment descriptions, maximum and minimum feed ranges and accuracy, and materials of construction when specific materials are required or precluded.
  - b. Location of feeders, piping layout, and points of applications.
  - c. Storage and handling facilities.
  - d. Specifications for chemicals to be used, including information regarding their certification for direct or indirect use in drinking water applications, when chemicals are specified.
  - e. Operating and control procedures including proposed application rates.
  - f. Descriptions of testing equipment and procedures.
2. CHEMICAL APPLICATION – Chemicals should be applied to the water at such points and by such means as to:
  - a. Provide a high degree of safety to the consumers and operators of a PWSS.
  - b. Provide adequate flexibility of operation through various points of application, when appropriate.
  - c. Prevent backflow or back siphonage between multiple points of feed through a common manifold, and prevent overdosing due to siphoning.
  - d. Prevent clogging, deterioration, or malfunctioning of valves, sluice gates, or other equipment, e.g., do not add lime slurry just upstream from a sluice gate.
  - e. Facilitate cleaning, maintenance, and proper mixing of chemicals and water.

- f. Chemical feed points should be located at an adequate distance upstream of where treatment sequences divide and where samples are collected to ensure thorough mixing and distribution of the chemical in the water being treated.

### 3. FEED EQUIPMENT

#### a. NUMBER OF FEEDERS

- 1) A separate feeder shall be used for each chemical applied except where the feeder can be used for other chemicals after appropriate cleaning and adjustments.
- 2) Where chemical feed is required for the protection of the PWSS, e.g., for disinfection, coagulation, or other essential processes, standby feeders are required.
- 3) The capacity of the standby unit or the combined capacity of the remaining units in service should be able to replace the largest unit when it is out of service.
- 4) Spare parts should be available for all feeders.

#### b. DESIGN AND CAPACITY

- 1) Feeders should be able to supply at all times the necessary amounts of chemicals at an accurate rate (+/- 5 percent) throughout the expected feed ranges.
- 2) Chemical feeders should be adjustable so that the chemicals can be added in proportion to flow or the amount of contaminant in the untreated water. Provisions should be made for measuring the quantities of chemicals used.
- 3) Weighing Scales
  - a) Shall be provided for weighing cylinders at all plants utilizing chlorine gas.
  - b) Should be provided for fluoride solution containers.
  - c) Shall accurately measure increments of one percent of the maximum load of the scale.

- 4) Positive displacement type solution feed pumps should generally be used to feed liquid chemicals. However, centrifugal pumps are approved for delivering coagulants. Pumps requiring check valves should not be used to pump slurries. Pumps must be sized to match or exceed maximum head conditions found at the point of injection.
  - 5) Service supply water lines shall be protected from possible contamination by chemical solutions using either of the following:
    - a) Equipping the supply and feed lines with backflow or back siphonage prevention devices.
    - b) Providing an air gap between the supply line and the solution tank.
  - 6) Contact materials and surfaces shall be resistant to the aggressive nature of the chemical solutions being employed.
  - 7) Dry chemical feeders with solution tanks should be designed to provide adequate solution water and agitation of the chemical in the solution pot, and to provide for gravity feed.
  - 8) Chemical bins or dry tanks should be completely enclosed to minimize dust releases to the operating room and to the outdoors. All bins should be equipped with dust collector bags.
  - 9) No direct connection shall exist between any sewer and a drain or overflow from the feeder or solution chamber or tank by providing that all drains terminate at least 6 inches (15.2 cm) or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit, or waste receptacle.
- c. LOCATION – Chemical feed equipment should:
- 1) Be located reasonably close to the point of application.
  - 2) Be readily accessible for servicing, repair, observation and operation.
  - 3) Be located in a separate room to reduce hazards and dust problems.
  - 4) Be provided with protective curbing or other spill containment so that chemicals from equipment failure, spillage, or accidental drainage will not enter the water in conduits, treatment basins, or storage basins; disperse into high personnel traffic areas; or be discharged out onto bare ground.

d. FEED LINES – Chemical feed lines should be:

- 1) Separate, with each chemical carried in a separate line.
- 2) Accessible, yet adequately protected, i.e., exposed lines and lines encased in concrete floors or walks should be avoided. Lime slurry should be carried in an open flume or other readily cleaned conduit where possible, and the line should be readily accessible to permit inspection.
- 3) Reasonably short in length; of durable, corrosion resistant material; easily accessible throughout the entire length; protected against freezing; and readily cleanable.
- 4) Adequately sloped upward from the source to provide drainage where condensation or reliquefaction of gases may occur, or adequately sloped downward from the source to prevent pumps from being vapor locked by liquid chemicals prone to degassing. In the latter case, siphoning must be prevented.
- 5) Designed to minimize the corrosive potential of chemicals, e.g., through the use of dilution water and diffuser systems.
- 6) Designed to avoid scale formation or solids deposition by the water, chemical, solution, or mixture conveyed.
- 7) Color coded (Table III-1 in Chapter III, General Facilities Considerations).

e. CONTROLS

- 1) Feeders may be manually or automatically controlled, but automatic controls must be capable of manual operation when necessary.
- 2) Automatic chemical dose or residual analyzers are desirable and should be fitted with alarms for critical values, and with recording charts or with digital readouts and computerized data loggers.
- 3) At automatically operated facilities, chemical feeders shall be electrically interconnected with the delivery pumps. Receptacles for automatically operated chemical feeders shall be non-standard.
- 4) Include provisions to track the quantities of chemicals used.

f. SOLUTION TANKS

- 1) Each solution tank shall be constructed or lined with a material that is compatible with the chemical solutions to be stored in it and certified by the tank supplier for each use.
- 2) Means should be provided in a solution tank to maintain a uniform strength of solution consistent with the nature of the chemical solution. Continuous agitation is necessary to maintain slurries in suspension.
- 3) Two solution tanks of adequate volume may be required to assure the continuity of a chemical supply during the servicing of a solution tank.
- 4) Each tank should be provided with a valved drain.
  - a) All drains should terminate at least 6 inches (15.2 cm) or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit, or waste receptacle.
  - b) In no case should drains discharge directly into sewers, streams, or water treatment flow. Preferably these discharges should drain to a sump from which they can be disposed of safely.
- 5) Solution tank design should include provisions to indicate the liquid level in the tank.
- 6) Chemical solutions should be kept covered. Large tanks with access openings should have such openings curbed and fitted with overhanging covers.
- 7) Subsurface locations for solution tanks or other types of feed tanks will not be approved.
- 8) Overflow pipes, when provided, should be turned downward with their ends screened, have free discharges, and be located where noticeable. Overflow and vent pipes should be kept separate in order to maximize the protection of the tank from overpressure and vacuum scenarios.
- 9) Provide protective curbing to prevent chemicals from equipment failures, spillages, or accidental discharges from entering into the water in conduits, treatment basins, or storage basins.

- 10) Solution tanks shall be properly labeled to designate their contents.

g. DAY TANKS

- 1) Day tanks shall be provided where bulk storage of liquid chemical is provided. KDHE may, on a case-by-case basis, waive the requirement for a day tank provided the bulk storage and feed system designs for a liquid chemical can without exception demonstrate that an overfeed will never occur. Under no circumstances will the day tank requirement be waived for the practice of fluoridation.
- 2) Day tanks shall meet all the requirements for solution tanks.
- 3) Day tanks should hold no more than a 30-hour supply for the average plant flow and average chemical dosages.
- 4) Day tanks shall be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod extending above a reference point at the top of the tank, attached to a float may be used. The ratio of the area of the tank to its height must be such that unit readings are meaningful in relation to the total amount of chemical fed during the day.
- 5) Hand pumps may be provided for transfer from a carboy or drum. A tip rack may be used to permit withdrawal into a bucket from a spigot. Where a motor-driven transfer pump is provided, a liquid level limit switch and an overflow line from the day tank must also be provided.
- 6) A means consistent with the nature of the chemical solution shall be provided to maintain uniform strength of solution in a day tank. Continuous agitation shall be provided to maintain chemical slurries in suspension.
- 7) Tanks shall be properly labeled to designate their contents.

h. SERVICE SUPPLY WATER

- 1) Water used for dissolving dry chemicals, diluting liquid chemicals, or operating chemical feeders shall be:
  - a) Only from a safe, approved source.
  - b) Protected from contamination by appropriate means.

- c) Ample in quantity and adequate in pressure.
  - d) Provided with means for measurement when preparing specific solution concentrations by dilution or for use in determining chemical feed rates.
  - e) Properly treated for hardness when necessary.
  - f) Obtained from a location sufficiently downstream of any chemical feed point to assure adequate mixing.
- 2) Where a booster pump is required, duplicate equipment should be provided, and when necessary, standby power.
  - 3) Backflow prevention should be achieved by appropriate means such as:
    - a) An air gap between the fill pipe and the maximum flow line of the solution or dissolving tank at least two pipe diameters, but not less than 1 inch (2.5 cm).
    - b) An approved reduced pressure zone backflow prevention device, consistent with the degree of hazard, aggressiveness of chemical solution, and available means for maintaining and testing the device.
    - c) Other backflow prevention assemblies or devices more appropriate for a specific application may be approved provided they are consistent with the KDHE's requirements for cross-connection control programs.

#### 4. CHEMICALS

##### a. QUALITY

- 1) Chemicals shall meet the most recent requirements of applicable AWWA standards and NSF International's ANSI/NSF Standard 60: Drinking Water Treatment Chemicals – Health Effects, or equivalent, be acceptable to KDHE, and shall protect public health and the environment (KAR 28-15-18(h)).
- 2) Assays for chemicals delivered may be required.

- 3) Chemicals having a distinguishing color may be used, providing the coloring material is not toxic in the concentrations used and will not impart taste and odor or color to the treated water supply.

b. SHIPPING CONTAINERS

- 1) A shipping container shall be both compatible with its contents and appropriate in style of construction to facilitate its handling and the transfer and/or application of the chemical in the treatment process.
- 2) Name of chemical, purity, and concentration shall be clearly indicated on the container label.
- 3) Supplier name and address shall be clearly indicated on the container label.
- 4) All relevant certifications shall be clearly indicated on the container label as is required by the certifying entities.

- c. PROTECTIVE MEASURES – Recommended safety requirements and protective measures for handling of all chemicals utilized by a PWSS should be determined and recorded in the PWSS's safety procedures manual. Sources of information about a particular chemical include the Material Safety Data Sheet, product label, chemical manufacturer, associated trade associations such as The Chlorine Institute, and relevant information compiled by regulatory agencies. These safety procedures should be reviewed regularly with all personnel. New employees who may be exposed to a chemical in handling or storage should be thoroughly instructed in the PWSS's safety requirements and protective measures for the chemical.

d. STORAGE

- 1) The space provided shall be sufficient for:
  - a) At least 30 days of chemical supply based on the average flow and dosage conditions; however, space needs should be adjusted to account for delivery time and needs for maximum process conditions.
  - b) Convenient and efficient handling of each chemical stored.
- 2) Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals unless the facilities are completely purged or cleaned before an alternate chemical is used.



- 3) Liquid chemical storage tanks shall have a liquid level indicator, an overflow pipe, a vent (separate from the overflow pipe), and either a receiving basin, capable of holding 110 percent of the stored volume, or a drain capable of receiving accidental spills or overflows. Hazardous materials may require extra precautions.
- 4) Special precautions shall be taken with materials requiring isolated, fireproof storage or explosion-proof electrical outlets, lights, and motors in the chemical handling areas.
- 5) Chemicals should be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.
- 6) Acid storage tanks shall be vented to the outside atmosphere, but not through vents in common with other storage tanks or day tanks.

e. HANDLING

- 1) The materials of construction of pipes to be used in the transport of chemicals must be corrosion resistant at working temperatures and pressures.
- 2) Chemicals that are incompatible should not be fed, stored, or handled together.
- 3) Provisions should be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers to minimize the quantity of dust that may enter the room in which the equipment is installed or be released to the outdoors. Control should be provided by use of:
  - a) Vacuum pneumatic equipment or closed conveyer systems.
  - b) Facilities designed specifically for emptying shipping containers in special enclosures.
  - c) Dust filters and exhaust fan systems that place hoppers or bins under negative pressure.
- 4) Carts, elevators, and other appropriate means should be provided for lifting and moving chemical containers to minimize handling by operators.

- 5) Provisions should be made for disposing of empty bags, drums, or barrels, either by burning or by some other approved procedure that will minimize exposure to dusts.
- 6) Provision should be made for the proper transfer of dry chemicals from storage to the chemical feed device so as to minimize the quantity of dust that may enter the room. Gravity and conveyer systems should be dust tight and adequately ventilated.
- 7) Appropriate vibrators, live bottoms, air sweeps or other devices should be installed on bulk storage bins to prevent bridging and compaction of stored materials.

f. HOUSING

- 1) Structures, rooms, and areas accommodating chemical feed equipment and storage containers should provide dry conditions and convenient access for servicing, repair, observation and operation.
- 2) Floor surfaces should be smooth, impervious, and well-drained with a minimum slope of 2 inches (5.1 cm) per 10 ft. (3.0 m). Where slipping hazards are a concern, particularly at facilities that utilize slippery materials in their treatment sequence such as polymers, a coarse non-slip floor finish or grit-top grating should be considered.
- 3) Open basins, tanks, and conduits should be protected from chemical spills or accidental drainage.
- 4) Pipes and feed lines through interior walls should be sealed with non-shrink grout or some other positive means.
- 5) Vents from feeders, storage facilities, and equipment exhaust shall discharge to appropriate pollution control devices before being safely released to the atmosphere at an elevation that is adequately above grade and at a location that is sufficiently remote from all air intakes.

g. OPERATOR SAFETY

- 1) Open basins, tanks, and conduits should be protected from chemical spills or accidental drainage.
- 2) At least one pair of rubber gloves, a dust respirator of a type approved by NIOSH for toxic dusts, and an apron or other protective clothing should be provided for each operator on any shift who will handle dry

chemicals. A deluge shower and an eyewash device should be installed where strong acids and alkalis are used or stored.

- 3) A water holding tank that will allow water to come to room temperature must be installed in the water line feeding the deluge shower and eyewash device. Other methods of water tempering will be considered on an individual basis.
- 4) Facilities should be provided for washing of an operator's person, apparel and protective equipment.
- 5) Other protective equipment shall be provided as necessary.

h. **HAZARDOUS MATERIAL HANDLING AND SPILLS**

Safety provisions for handling hazardous materials and reporting spills of hazardous materials shall be in accordance with all local, state and federal requirements. Risk management plans are required for systems storing regulated materials such as chlorine and ammonia in excess of the threshold amounts specified in the pertinent sections below. Additional information regarding the requirements for storing hazardous materials may be found in the Clean Air Act (112r), OSHA (Section 654), EPCRA, and OSHA's Process Safety Management (29 CFR 1910.119) and Hazard Communication (29 CFR 1910.1200) rules. Security requirements and/or recommendations, in general and for facilities that store large quantities of hazardous materials, may be found in USEPA's "Chemical Accident Prevention: Site Security" (USEPA, 2000b) as well as on their website.

**B. CHLORINE GAS REQUIREMENTS**

Gas chlorination equipment, piping, and related appurtenances as well as handling practices shall conform to the specifications and recommendations of The Chlorine Institute (The Chlorine Institute, 1997).

1. **CHLORINATOR SPECIFICATIONS**

- a. For gas withdrawal systems, only solution-feed, vacuum-operated chlorinators shall be utilized in which chlorine gas is maintained under vacuum throughout the apparatus. Such systems typically employ a chlorine gas ejector that creates a partial vacuum into which chlorine gas is drawn from the cylinder and injected into the supply water to form a concentrated chlorine solution. The concentrated chlorine solution is conveyed through a corrosion-resistant conduit for application to the water being treated. Direct-feed chlorinators that deliver liquid or gaseous chlorine under positive pressure directly to the point of application will not be approved.

Other essential features of a solution-feed, vacuum-operated chlorinator include the following:

- 1) A flow regulating system that will automatically shut off chlorine feed and send an alarm (to the SCADA system, if available) upon loss of vacuum due to such causes as vacuum leak, stoppage in the chlorine solution discharge line, plugging of the ejector, or loss of pressure in the water supply line.
  - 2) Chlorine feed rate indicators appropriately sized for the desired feeding range. If there is a large difference in feed rates between routine and emergency dosages, a feed-rate indicator should be provided for each dosage range to ensure accurate control.
  - 3) A means for setting or controlling the rate of chlorine such as a regulating diaphragm assembly. Automatic proportioning feed rate controls shall be provided where the rate of flow or chlorine demand is not reasonably constant. The equipment shall be of such a design that it will operate accurately over the desired feed range.
  - 4) A check valve or other flow interlock device to prevent the backflow of water into the chlorinator.
  - 5) A means to vent gas to the outside or to a scrubber in the event that the chlorine feed regulating system should leak during shutdown.
  - 6) Gauges for measuring water pressure in the water supply line to the ejector and in the chlorine solution line at the outlet of the ejector. Further, a vacuum gauge should be provided in the vacuum line between the ejector and the chlorinator.
- b. Filters and traps ahead of chlorinator vacuum regulating valves and control apparatus are desirable to prevent impurities inherent in chlorine from plugging and damaging chlorine regulators and control mechanisms.
- c. Each chlorine gas ejector must be selected for the point of application with particular attention given to the quantity of chlorine to be added, the maximum ejector water flow, the total discharge back pressure, the required ejector operating pressure for creation of vacuum, and the size of the chlorine solution lines. In order to establish sufficient ejector operating pressure, a booster pump may need to be provided in the water supply line. The water supply to each ejector shall have a separate shut-off valve. A master shut-off valve will not be approved.

- d. The concentrated chlorine solution should be thoroughly mixed with the water being treated. The center of a pipeline is typically the preferred application point. A mixer or diffuser may be needed to adequately disperse the chlorine solution into the flow in a large conduit.
- e. An installed and operable chlorinator sufficient in capacity to replace the largest unit in service shall be provided. An installed and operable duplicate chlorinator shall be provided for smaller systems where only one chlorinator is required. Alternatively, a spare parts inventory sufficient to insure no interruption in the delivery of properly disinfected water may be provided.

## 2. CHLORINE CYLINDERS AND CONTAINERS

- a. Chlorine cylinders and containers should be fabricated to DOT and The Chlorine Institute's specifications (The Chlorine Institute, 1997).
- b. All cylinders and containers should be equipped with at least one pressure (or safety) relief device with provisions to appropriately direct a non-release, i.e., a small leak, to a ventilation system and a release to a scrubber. Fusible plugs/links do not need to be vented.
- c. Full and empty cylinders of chlorine gas shall be:
  - 1) Isolated from operating areas.
  - 2) Adequately secured by chains (if used in a vertical, upright position), trunnions or cradles (for one ton containers), or other devices.
  - 3) Stored in rooms separate from ammonia storage.
  - 4) Stored in areas not in direct sunlight or exposed to excessive heat.
  - 5) For the safe handling of a one ton container, a lifting bar of the type recommended by The Chlorine Institute must be used in combination with a hoist or crane having a capacity of at least 2 tons (1,814 kg). One ton containers must be stored so that they will not receive direct sunlight or be contacted by rain or snow. Trunnions should be provided for storing one ton containers.
  - 6) Scales must be provided to determine the amount of chlorine applied to the water as indicated by the loss in weight in the chlorine cylinders or containers.

### 3. CHLORINATOR PIPING

- a. **CROSS-CONNECTION PROTECTION** – The chlorinator's water supply piping shall be designed to prevent contamination of the treated water supply by sources of questionable quality. At all facilities treating surface water, pre-filter and post-filter chlorination systems must be independent to prevent possible siphoning of partially treated water into the clearwell.
- b. **PIPING** – Pipes carrying elemental liquid or dry gaseous chlorine under pressure must be Schedule 80 seamless steel tubing or other materials (never PVC) as recommended by The Chlorine Institute (The Chlorine Institute, 1997). Piping arrangements should be as short and simple as possible, preferably above ground. The number of pipe joints should be held to a minimum. Piping systems should be well supported and adequately sloped to allow drainage. Low spots should be avoided.
- c. **CONNECTING LINES** – Direct-cylinder mounted vacuum regulators or gas chlorinators are recommended where connecting two or more cylinders to a manifold is not necessary. This avoids the utilization of flexible connectors or other connecting pipe between the cylinder and the gas chlorinator and thus eliminates the significant safety hazards that would otherwise exist. Reliquefaction of gaseous chlorine upon a decrease in the temperature of the connecting line relative to the gas cylinder is not uncommon. Reliquefaction of chlorine within the connecting line may result in liquid chlorine reaching the chlorinator or lead to premature failure of the line itself. If a connecting line between the cylinder and the chlorinator must be utilized, reliquefaction may be prevented by installation of an external chlorine pressure reducing valve close to the cylinder or by insulating the line. Pressurized chlorine feed lines shall not carry chlorine gas beyond the chlorinator room.
- d. **COLOR CODING** – All piping carrying chlorine gas or chlorine solution should be color coded as specified in Table III-1 of Chapter III, General Facilities Considerations.
- e. **MATERIALS FOR CHLORINE SOLUTIONS** – Rubber, PVC, polyethylene, or other materials recommended by The Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.
- f. **THERMAL EXPANSION** – Suitable allowance should be made for pipe expansion due to changes in temperature. This is particularly true in the transport of liquid chlorine as it has a high coefficient of thermal expansion. High pressures can develop as the result of an increase in the temperature of the chlorine. This could result in hydrostatic rupture of the chlorine line. The

effects of a possible line rupture must be considered in the design of any piping system.

- g. **AUTOMATIC SWITCH-OVER** – Automatic switchover of chlorine cylinders or containers should be provided, where necessary, to assure continuous disinfection.
  - h. **WITHDRAWAL RATES** – The chlorine gas discharge (withdrawal) rate should not exceed 1.5 lbs/hr (0.68 kg/hr) from a single 100-lb chlorine cylinder, 1.8 lbs/hr (0.82 kg/hr) from a single 150-lb chlorine cylinder, or 15 lbs/hr (6.8 kg/hr) from a single one ton chlorine container. The assumptions underlying these permissible discharge rates include an ambient temperature around the cylinder or container of 60 °F (16 °C), natural air circulation, and a gauge pressure against which the cylinder or container is discharging of 21 psi (145 kPa). Higher withdrawal rates from cylinders or containers can be achieved by either manifolding multiple cylinders, or installing an evaporator to evaporate the liquid chlorine withdrawn from chlorine cylinders or containers.
4. **TESTING EQUIPMENT** – Chlorine residual test equipment employing a method recognized in the latest edition of *Standard Methods* (APHA *et al.*, 2005) shall be provided, and should be capable of measuring residuals to the nearest 0.1 mg/L. Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time. All treatment plants having a capacity of at least 0.5 MGD (1,893 m<sup>3</sup>/day) or serving a population greater than 3,300 persons should be equipped with recording chlorine analyzers monitoring water entering the distribution system. Consideration should be given to utilizing on-line chlorine analyzers to send an alarm to the SCADA system when chlorine residuals in the treated water are inadequate.
5. **RESPIRATORY PROTECTION EQUIPMENT** – Respiratory protection equipment meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) shall be available where chlorine gas is handled, and shall be stored outside every room where chlorine is used or stored. Respiratory protection equipment may consist of either an air purifying respirator (canister gas mask type) designed for chlorine gas or an air supplied respirator such as a self-contained breathing apparatus.

Air supplied respirators are recommended over air purifying respirators for the following reasons. Air purifying respirators do not compensate for the lack of oxygen. A minimum of 19.5 percent oxygen by volume must be present before such respirators can be used. They are also subject to the manufacturer's stated use limitations for the particular contaminant. Most chlorine releases are at low concentrations and canister gas masks would ordinarily offer adequate protection. However, it would not be possible to confirm that a canister gas mask would offer

adequate protection in all situations unless a reliable, continuously operated chlorine monitoring/detection/alarm system was located in the vicinity of the leak.

6. CHLORINE GAS FEED AND STORAGE ROOM SPECIFICATIONS

- a. Chlorine gas feed and storage areas shall be enclosed and separated from other operating areas. Each room shall be:
  - 1) Provided with a shatter resistant, gas tight, inspection window installed in a door or interior wall of the chlorine room to permit the chlorinator(s) to be viewed without entering the room.
  - 2) Constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed.
  - 3) Provided with doors equipped with panic hardware, assuring ready means of exit and opening outward only to the building exterior.
  - 4) Provided with sufficient space for a scale and storage of at least one spare cylinder or container for each one connected in service.
  - 5) Posted with appropriate warning signs as required by the emergency preparedness agency or local fire department having jurisdiction over the facility.
- b. Where chlorine gas is used, the room shall be reasonably gas tight and constructed as follows:
  - 1) Each room shall have a ventilating fan with a capacity of one complete air change per minute when the room is occupied.
  - 2) The ventilating fan shall take suction near the floor as far as practical from the door and air inlet, with the point of discharge so located as not to contaminate air inlets to any rooms or structures.
  - 3) Air inlets should be through louvers near the ceiling.
  - 4) Louvers for chlorine room air intake and exhaust shall facilitate airtight closure.
  - 5) Separate switches for the fan and lights shall be located outside of the chlorine room and at the inspection window. Outside switches shall be protected from vandalism. A single light indicating fan operation shall be provided at each entrance where the fan can be controlled from more than one point.



- 6) Vents from feeders and storage shall discharge to the outside atmosphere, above ground.
  - 7) The room location should be on the prevailing downwind side of the building away from entrances, windows, louvers, walkways, etc.
  - 8) Floor drains are strongly discouraged. Where provided, the floor drains shall discharge to the outside of the building and shall not be connected to other internal or external drainage systems.
  - 9) Federal regulations (40 CFR 68) promulgated under the authority of Section 112r of the Clean Air Act require utilities having an inventory of more than 2,500 lbs (1,134 kg) of chlorine to develop and implement a risk management plan (RMP). Such a plan may include a system that in the event of a measurable release of chlorine is automatically engaged into operation to collect and neutralize releases of liquid chlorine and/or a scrubber to capture and neutralize releases of chlorine vapor to prevent its discharge into the environment. The system shall be sized to treat the entire contents of the largest storage container on site. Design recommendations and guidance pertaining to such equipment and its operation are provided by White (1999) and The Chlorine Institute's *Chlorine Scrubbing Systems* (The Chlorine Institute, 1998). Local fire codes, especially those based on a regional or national model fire code, may place additional requirements on the storage of chlorine gas.
- c. Chlorinator rooms should be heated to 60 °F (16 °C) and protected from excessive heat. Cylinders and gas lines should be protected from temperatures above that of the feed equipment.

7. LEAK DETECTION, REPAIR AND RECOVERY

- a. A bottle of concentrated ammonium hydroxide solution (56 percent ammonia by weight) shall be available for chlorine leak detection. A white cloud will form when the solution makes contact with chlorine from a leak.
- b. Continuous chlorine leak detection equipment is recommended. Where a leak detector is provided it shall be equipped with both an audible alarm and a warning light. Chlorine monitoring equipment which continuously samples the air and detects the presence of chlorine is available and should be considered in any storage or operating area where chlorine can be released.
- c. Leak repair kits approved by The Chlorine Institute shall be provided where chlorine cylinders, containers, tank cars and tank trucks are used. These kits can be utilized to contain valve leaks by applying hoods and gaskets. Patches

are provided for sealing off small holes in the side wall of cylinders and containers.

- d. Chlorine recovery vessels are recommended where 150-lb chlorine cylinders are used. Chlorine from the leaking cylinder may be recovered from the vessel once the leaking cylinder has been secured inside the vessel.
- e. Consideration should be given to the use of remotely operated isolation valves where chlorine containers are employed. The isolation valve may be located directly on the chlorine container valve or alternatively in the chlorine line leading from the chlorine container, but as close to the chlorine container as possible.

## C. OTHER CHEMICALS

### 1. HYPOCHLORITES

- a. **STABILITY** – Even under ideal storage conditions hypochlorite solutions gradually decompose. For example, utilizing decomposition rate equations developed by The Chlorine Institute, a 15-percent available chlorine sodium hypochlorite solution is estimated to decompose to 7.5-percent available chlorine in 136 days in storage at 65 °F (18 °C) (The Chlorine Institute, 2000). The rate of hypochlorite decomposition increases with increasing concentration and temperature, is more rapid at pH values below 11, and is catalyzed by light and metal impurities, especially iron, copper, and nickel. To minimize the loss of available chlorine and to minimize the formation of chlorite and chlorate (byproducts of hypochlorite decomposition), the following practices are recommended:
  - 1) Manage the hypochlorite inventory to avoid unnecessarily long storage times (with 28 days being a reasonable target) consistent with the need to ensure continuous disinfection;
  - 2) Dilute hypochlorite solutions upon receipt (to 5 to 10 percent available chlorine), preferably with softened water to minimize softening reactions that may require periodic removal of precipitates from the storage tank and to reduce the concentrations of metals that catalyze the decomposition of hypochlorite;
  - 3) Store hypochlorite solutions in the dark and at a temperature below 70 °F (21 °C) and at pH 11.0 to 11.2 (higher pH values do not improve stability, but may increase the chemical dosages needed for stabilization of the finished water);

- 4) Specify hypochlorite solutions free of sediment and suspended solids and having less than 0.5 mg/L of iron, copper and nickel (White, 1999); and
  - 5) Avoid bringing hypochlorite solutions into contact with incompatible materials.
- b. CONTAINERS – Sodium hypochlorite solution is often shipped in 5 and 55 gallon (19 and 210 L) drums and stored in the drums prior to use. The drums must meet DOT specifications and are generally manufactured of polyethylene. Sodium hypochlorite solutions of 7 percent by weight or greater must be stored in vented containers. If the venting rate is exceeded by the decomposition rate, swelling of the container may be apparent. Care must be taken when opening containers containing sodium hypochlorite solutions to detect and properly release excess pressure.
- c. MATERIALS – As a general rule, metal should not be allowed to come in contact with sodium hypochlorite solution. Mild steel, stainless steel, and virtually all common metals will corrode rapidly on contact with sodium hypochlorite solutions and, in turn, the solutions will decompose much more rapidly.

Plastic pipe is commonly employed to carry hypochlorite solutions, however great care must be exercised in the selection of materials for this service. It is at a minimum important to evaluate chemical compatibility, structural limitations with respect to operating and surge pressures, and joint integrity. Where glued pipe is employed, the solvent cement utilized during construction of the pipe system must be compatible with both the pipe material and the hypochlorite solution.

Schedule 80 PVC is the most commonly used pipe material; but PVC pipe can develop cracks after prolonged exposure to hypochlorite solutions (White, 1999). PVDF is the preferred material for both pipe and fittings (White, 1999). CPVC, though more expensive than PVC, has been found to provide better resistance to hypochlorite, especially when it is exposed to UV light or temperatures above 73 °F (23 °C) (White, 1999)(Joslyn and Gaddis, 2001). Steel pipes lined with polypropylene, PVDF, or PVDC can also be used, especially for underground piping (White, 1999); and steel valves lined with PVC, PVDC, PVDF or hard rubber, are acceptable (AWWA and ASCE, 2005).

Storage tanks should be constructed of FRP, polyethylene, or steel lined with rubber or polyethylene (White 1999); but the resin used in an FRP tank (and in either wall of a double-walled tank) must be compatible with hypochlorite (Joslyn and Gaddis, 2001). In general, it is important that the processes

utilized to manufacture FRP tanks employ appropriate resins and catalyst setting systems, and that the tanks be post cured. Diffusers should be made of PVC, PVDF, or rubber-lined and covered steel (White, 1999).

- d. **DANGEROUS REACTIONS** – Hypochlorites should never be mixed with acids, ammonia solutions, or solids containing ammonium salts. Hazardous gases may be formed; and excessive heat or pressure may be generated. Further, hypochlorites may react violently with many organic compounds including greases, oils, fuels, etc.
- e. **PERSONAL PROTECTION** – When handling calcium or sodium hypochlorite, it must never be allowed to contact the eyes. Hypochlorites can cause serious burns on the skin and damage to the lungs. When handling these materials, the operator should wear a protective apron, rubber gloves, eye protection, and respiratory equipment.
- f. **GAS RELEASE** – Hypochlorite releases small amounts of gas (oxygen) as it decomposes. Gas buildup has reportedly led to failure of PVC ball valves (AWWA and ASCE, 2005) and can cause vapor lock in feeding systems. Vapor lock, and the underdosing associated with it, can be avoided or minimized by: using gravity feed systems; using flow meters or rotameters to verify feed rates; installing degassing valves; and sloping tubing or piping downward toward the feed pumps to allow gas bubbles to escape back into the storage tank (Joslyn and Gaddis, 2001).
- g. **FEEDERS** – Positive displacement pumps with hypochlorite compatible materials for wetted surfaces are recommended. Small diameter suction lines should be used with foot valves in smaller installations. In larger installations, flooded suction should be used with piping arranged to promote escape of gas bubbles. Calibration tubes or mass flow monitors which allow for direct physical checking of actual feed rates should be employed.

## 2. ACIDS AND CAUSTICS

- a. Acids and caustics shall be kept in closed, corrosion-resistant, shipping containers or storage units.
- b. Acids and caustics shall not be handled in open vessels, but should be pumped in undiluted form from original containers through suitable hoses, to the point of treatment or to a covered day tank.

## 3. SODIUM CHLORITE FOR CHLORINE DIOXIDE GENERATION – Chlorine dioxide is generated on-site because of its explosive properties when stored. It is continuously generated, typically by oxidizing sodium chlorite with aqueous or gaseous chlorine or electrochemically. Several different methods are employed

commercially. Proposals for the storage and use of sodium chlorite must be approved by KDHE prior to the preparation of final plans and specifications. Provisions shall be made for proper storage and handling of sodium chlorite to eliminate any danger of explosion.

a. STORAGE

- 1) Sodium chlorite shall be stored by itself in a separate room and preferably stored in an outside building detached from the water treatment facility. It must be stored away from organic materials, many of which will catch fire and burn violently should they come in contact with chlorite, and shielded from exposure to sunlight, UV light, and heat, which will reduce product strength and increase byproduct formation. Shielding is recommended by the USEPA's *Guidance Manual for Alternative Disinfectants and Oxidants* (USEPA, 1999b).
- 2) The storage structure shall be constructed of noncombustible materials.
- 3) If the storage structure must be located in an area where a fire may occur, water sprinklers must be available to keep the sodium chlorite area cool enough to prevent decomposition from heat and the resultant explosive conditions.
- 4) High-density polyethylene is recommended over fiber-reinforced polyester or plastic for storage and day tanks. If fiberglass is used, the proper resins must be selected, since some polymers will degrade in contact with chlorite (Gates, 1998).
- 5) Secondary containment should be provided in storage and handling areas, including sumps to facilitate product recovery; and a water supply should be available for cleanup. Additional information can be found in USEPA's *Guidance Manual for Alternative Disinfectants and Oxidants* (USEPA, 1999b).

b. HANDLING

- 1) Care should be taken to prevent spillage.
- 2) An emergency plan of operation should be available for the clean up of any spillage. Sprinklers shall be provided in housed handling facilities. Adequate ventilation and air monitoring devices should be provided, and gas masks and first aid kits should be available immediately outside the storage area. Additional information can be

found in USEPA's *Guidance Manual for Alternative Disinfectants and Oxidants* (USEPA, 1999b).

- 3) Storage drums must be thoroughly flushed prior to recycling or disposal.

c. **FEEDERS**

- 1) Positive displacement feeders shall be provided for sodium chlorite, sodium hypochlorite, or acid feed, except for systems designed to operate under vacuum. Whether positive displacement or vacuum feeders are used, appropriate safeguards shall be included to insure steady chemical feed rates, to prevent air binding, to prevent chemicals from being siphoned out of, or drawn back into, storage containers or from mixing with one another outside the reaction zone or in unsafe proportions, and to provide adequate safety.
- 2) Tubing for conveying sodium chlorite or chlorine dioxide solutions shall be Schedule 80 CPVC, PTFE, polyethylene, or other materials recommended by the manufacturer. Lines carrying chlorite solutions or chlorine dioxide should never be plumbed directly over foot traffic.
- 3) Chemical feeders may be installed in chlorine rooms if sufficient space is provided or facilities meeting the requirements of chlorine gas shall be provided.
- 4) Feed lines shall be installed in a manner to prevent formation of gas pockets, and shall terminate at a point of positive pressure.
- 5) Check valves shall be provided to prevent the backflow of chlorine into the sodium chlorite line.

4. **AMMONIA**

- a. Ammonia may be fed directly under vacuum or in the form of an ammonium solution prepared from anhydrous ammonia, concentrated aqua ammonia, or ammonium sulfate.
- b. When using anhydrous ammonia, only solution-feed, vacuum-operated gas withdrawal and delivery systems shall be utilized in which anhydrous ammonia gas is maintained under vacuum throughout the apparatus. Liquified anhydrous ammonia causes severe burns on skin contact and is highly toxic when volatilized and inhaled so special precautions must be taken when using this chemical to adequately protect the health and safety of both plant personnel and the public. The equipment and facilities required to

feed anhydrous ammonia are similar to those used to feed chlorine gas (Section B), except that the emergency air exhaust system shall have an elevated intake and special vacuum breakers and regulators must be used to avoid the potentially violent results of backflow of water into a cylinder or storage tank. Direct-feed of liquified or gaseous anhydrous ammonia under positive pressure directly to the point of application will not be approved.

- c. Typical piping materials for solution feed systems are stainless steel, PVC, and black iron; but PVC is used only in the lower-pressure portions of the system and for conveying aqua ammonia, which is highly corrosive (USEPA, 1999b). KDHE recommends the use of black steel pipe for this service since PVC and CPVC have been known to become extremely brittle and break, e.g., shatter like glass, very easily in this service. Copper, bronze, and brass fittings may not be used because ammonia attacks copper as well as copper-based and copper-bearing alloys. Zinc, cadmium, and all of their alloys are also readily attacked by ammonia solutions (Terra Industries, Inc., 2002).
- d. Systems utilizing anhydrous ammonia or aqua ammonia must be designed to prevent the release of hazardous or irritating amounts of ammonia gas. Systems storing more than 10,000 lbs (4,536 kg) of anhydrous ammonia or 20,000 lbs (9,072 kg) of aqua ammonia (20% by weight or greater) are required under Section 112r of the Clean Air Act (40 CFR 68) to prepare risk management plans. The ventilation design requirements for rooms utilized to store anhydrous and aqua ammonia shall follow the requirements for chlorine rooms. Scrubbers may be required to protect the health and safety of employees and the public.
- e. Chlorine gas and anhydrous ammonia, aqua ammonia or ammonium sulfate solutions may not be stored in the same room, and ammonia gas application points must be located at least 5 ft. (1.5 m) away from chlorine solutions lines.
- f. Tanks used for outdoor storage of anhydrous ammonia should be protected from extreme temperatures ( $< 28^{\circ}\text{F}$  ( $-2.2^{\circ}\text{C}$ ) and  $> 125^{\circ}\text{F}$  ( $52^{\circ}\text{C}$ )). Tanks should be painted white, and supplemental heat may be needed during the winter to prevent impairment of ammonia vaporization.
- g. Both atmospheric and pressurized tanks have been utilized to store aqua ammonia, however, KDHE recommends pressurized tanks over atmospheric tanks for bulk storage as atmospheric storage tanks can represent a direct hazard to operating personnel and the surrounding community. Aqua ammonia solutions stronger than 19% by weight should be stored in closed, pressurized tanks, while aqua ammonia solutions with concentrations of up to 19% by weight can be stored in atmospheric tanks fabricated to API 650 Code (Terra Industries, Inc., 2002). Regardless of choice, KDHE

recommends that aqua ammonia storage, transfer and feed systems be designed by qualified personnel having previous experience with the product.

Pressurized bulk storage tanks and transfer facilities shall be sited outdoors and away from enclosed areas. Common materials of construction are carbon steel and stainless steel. Passivation is recommended where carbon steel is selected. Pressurized bulk storage tank design generally consists of low pressure bullet-shaped tanks designed to ASME Section 8, Division 1 Code for working pressures of 30 psig or greater (Terra Industries, Inc., 2002). Bulk storage tanks should be fitted with both a safety relief device and a vacuum breaker to prevent rupture and collapse, respectively, and be grounded. Unloading facilities shall include an ammonia vapor return line to the delivery tanker. Transfer of product may be accomplished by tanker or customer off-loading pumps. Vapor lines and liquid lines should be 1 to 1.25 inches (2.5 to 3.2 cm) and 2 inches (5.1 cm) in diameter, respectively (Tanner Industries, Inc., 1998). A connector incompatible with other chemical deliveries or other lockout provisions shall be made to prevent accidental addition of other chemicals to the storage tank. If the aqua ammonia feed system utilizes a carrier stream to convey aqua ammonia to the treated water stream, the carrier water must be softened water.

Atmospheric bulk storage tanks shall be corrosion resistant, vented through an inert liquid trap to a high point outdoors, adequately contained, and their storage areas well ventilated. Outside delivery connections, an ammonia vapor return line to the delivery tanker, tanker or customer product transfer pump(s), and a connector incompatible with other chemical deliveries or other lockout provisions to prevent accidental addition of other chemicals to the storage tank shall be included in the off-loading design. Aqua ammonia storage tanks shall be fitted with cooling/refrigeration units and/or provisions to dilute the contents with water (with adequate mixing and without opening the tank), such that temperature increases do not cause the vapor pressure of ammonia over the aqua ammonia to exceed atmospheric pressure. If the aqua ammonia feed system utilizes a carrier stream to convey aqua ammonia to the treated water stream, the carrier stream must be softened water.

- h. Aqua ammonia feed pumps and indoor storage facilities shall be enclosed and separated from other areas. The room shall be equipped similarly to that described in Subsection B.6, except that the exhaust fan shall withdraw air from high points in the room and air shall be allowed to enter at a low point. Aqua ammonia feed pumps, regulators, and lines shall be fitted with pressure relief vents discharging to the outside of the building and away from any air intake and with water purge lines leading back to the headspace of the bulk storage tank.



- i. The water used to prepare, dilute or carry an ammonium solution must normally be soft or softened to avoid precipitation of calcium carbonate (or calcium sulfate, if ammonium sulfate is used) and the subsequent clogging of the injector. The ammonia injector should consist of a perforated tube fitted with a closely fitting flexible rubber tubing seal punctured with a number of small slits to delay fouling by lime deposits. Provisions should be made for periodic removal of scale deposits from injectors and carrier piping.
  - j. Pressurized feed lines for anhydrous ammonia and full strength solutions of aqua ammonia shall be restricted to the ammonia storage/feed room. Chemical feed lines carrying a dilute aqua ammonium solution, including those prepared by dissolving anhydrous ammonia in water, shall be appropriately located to ensure optimal and safe delivery of the solution to the point(s) of application.
  - k. Leak detection systems shall be utilized in all indoor areas where anhydrous ammonia is stored or through which anhydrous ammonia is piped.
  - l. A solution of ammonium sulfate is prepared by adding ammonium sulfate to water with agitation. The tank and dosing equipment contact surfaces should be made of corrosion resistant non-metallic materials. Provision should be made for removal of the agitator after dissolving the solid. The tank should be fitted with a lid and vented outdoors.
  - m. Ammonium solutions should be injected below the surface of the water being treated, preferably in the center of the treated water flow, at a location where the water is flowing at a high velocity or has sufficient turbulence to thoroughly mix the ammonium solution with the water being treated. To avoid the release or irritating or harmful vapors, especially when using solutions prepared from anhydrous ammonia or aqua ammonia, concentrated streams of feed solution must not be allowed to rise to the surface of the water being treated.
5. LIME SLURRY – Provisions shall be made to minimize scaling of the pumps, feed lines, troughs and other equipment used for preparing and conveying lime slurries and to facilitate scale removal. Recommendations regarding lime feeding, including scale control and removal, are available from the National Lime Association (1995).
6. POWDERED ACTIVATED CARBON – PAC shall be handled as a potentially combustible material. It should be stored in a building or compartment as nearly fireproof as possible. Overhead sprinklers are recommended as a precautionary measure. Other chemicals should not be stored in the same place. PAC is not normally explosive, however, it is combustible and will burn when ignited. PAC may not be stored where it can come in contact with gasoline, mineral or vegetable oils; and PAC should never be mixed with or stored near disinfecting or oxidizing

agents. Since activated carbon is an electrical conductor, PAC dust should not be allowed to accumulate near or on open electrical circuits. PAC can be stored as a slurry up to one year without affecting its adsorptive capacity, provided that it is adequately protected from contaminants.

PAC, in dry or slurry form, adsorbs oxygen from the air. Therefore, enclosed spaces where PAC is stored must be adequately ventilated and equipped with oxygen monitors, alarms, and other appropriate safety features.

7. POLYPHOSPHATES – Stock phosphate and polyphosphate solutions should be covered and disinfected by carrying a free chlorine residual of approximately 10 mg/L. Phosphate solutions having a pH of 2.0 or less may be exempted from this requirement by KDHE.
8. POLYMERS – Polymer tanks may require protective paint or plastic liners. Dilution of stock polymers prior to feeding is common. Materials of construction and arrangement of the delivery system should be according to the manufacturer's recommendation. Facilities that utilize polymers should consider a coarse non-slip floor finish or grit-top grating for polymer area floors to minimize slipping hazards.
9. ACTIVATED ALUMINA – Activated alumina should be stored away from gasoline, minerals or vegetable oils, and calcium hypochlorite (AWWA and ASCE, 2005).